PROJECT SUMMARIES

INERTIAL MOTION TRACKING TECHNOLOGY FOR INSERTING HUMANS INTO A NETWORKED SYNTHETIC ENVIRONMENT

Eric R. Bachmann, Instructor
Robert B. McGhee, Professor
Michael J. Zyda, Professor
Department of Computer Science
Sponsors: U.S. Army Research Office and Naval Postgraduate School

OBJECTIVE: The goal of this project was to show the feasibility of tracking angular motion of human limb segments using miniaturized inertial and magnetic sensing devices together with an innovative quaternion-based nonlinear attitude estimation filter. This effort was initially undertaken with NPS Institutional Funded Research funds to provide the basis for a proposal to the U.S. Army Research Office (ARO) to develop and test a full instrumented "body suit" capable of tracking the motion of fifteen human limb segments in real-time and displaying the results over a computer network as realistic 3D motion of an articulated body model of a human figure.

SUMMARY: All goals of the first year of this project have been accomplished. A miniaturized nine-axis sensor system (three axes each of linear acceleration, angular rate, and ambient magnetic field) was designed and constructed. Prototype software was developed by simulation means. The results of these two efforts were combined and functioned correctly. A proposal to the U.S. Army Research Office, Durham, for a two-year project aimed at the development of a full body suit was submitted and subsequently funded in February 1998. The experimental parts of two master's theses relating to this research have been completed. A paper based on these theses (listed below) has been written and submitted for review. Work in the coming year will be concentrated on investigations relating to full body tracking and display using multiple copies of the sensor package developed during the current year along with an enhanced software system.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Modeling and Simulation

KEYWORDS: Body Tracking, Virtual Reality, Human-Computer Interface

EVALUATION OF C3 ASPECTS OF THE PROJECT ALBERT

Wolfgang Baer, Research Assistant Professor
Department of Computer Science
Sponsor: Marine Corps Combat Development Command

OBJECTIVE: Develop a set of spatio-temporal measures of combat potentials appropriate to the MAGTF Commander in an Operational Maneuver From Sea (OMFTS).

SUMMARY: Utilizing LOS and Perspective View capability developed at NPS, this project explored the capability of calculating weapons effectiveness potentials for close air support, direct fire, and indirect fire weapons. The resulting potentials are color coded on a high-resolution photo map display at near real time rates. The system is expected to be integrated into constructive tactical battlefield simulations such as JANUS in order to provide weapons effectiveness feedback to the commanders.

CONFERENCE PRESENTATIONS:

Baer, W., "Performance Modeling of Parallel Programs in SMP Environments," 6th INFORMS Computer Science Technical Section Conference, Monterey, CA, 7-9 January 1998.

Baer, W., "EO/IR Data Dictionary and Beyond," SISO Synthetic Environment and Sensor Forum, San Diego, CA, 14-15 January 1998.

Baer, W., "Line of Sight and Perspective View Server for Windows NT," 66th Military Operations Research Society Symposium, Monterey, CA, 23-25 June 1998.

Baer, W., "After Action Review System on UNIX and Windows NT," 66th Military Operations Research Symposium Poster Session, Monterey, CA, 23-25 June 1998.

Rowe, N., Reed, C., Baer, W., and Jackson, L., "A Planner for Constructing Customized Terrain Databases," 1998 Command and Control Research and Technology Symposium, Monterey, CA, June 1998.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Weapons Effectiveness)

KEYWORDS: Weapons Effectiveness, High Resolution Terrain, Modeling Simulation

HIGH RESOLUTION TERRAIN SYSTEM DEVELOPMENT I AND II
Wolfgang Baer, Research Assistant Professor
Department of Computer Science
Sponsor: U.S. Army Test and Experimentation Command

OBJECTIVE: Develop line-of-sight and perspective view server using 1-meter terrain.

SUMMARY: This project developed a high speed line-of-sight (LOS) and video realistic perspective view generation (PVG) in low cost PC based hardware running Windows NT. Utilized advances in disk capacity, execution speed, and symmetric multi-processing configurations allow scalable servers to be built which can provide LOS and PVG services in an interactive networked environment at low costs. The server is now available in low cost PC based hardware running Windows NT.

The server was a component of an After Action Review Systems supporting trial control and post trial analysis in operational tests being integrated by TEXCOM at Fort Hood, TX. The system components included a rapidly configurable PV-Wave graphics interface networked with a high-speed line-of-sight (LOS) and the video realistic perspective view generator (PVG) server.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: High Resolution Terrain, Databases, Modeling Simulations

AUTOMATION SUPPORT FOR SOFTWARE EVOLUTION
Valdis Berzins, Professor
Department of Computer Science
Sponsor: U.S. Army Research Office

OBJECTIVE: The objective of the proposed effort is to design a system for automating the configuration management needed to keep track of the evolution of a software prototyping during a typical application of the evolutionary software prototyping method supported by the Computer-Aided Prototyping System (CAPS). CAPS is an integrated software development environment aimed at rapidly prototyping hard real-time embedded software systems, such as missile guidance systems, space shuttle avionics systems, robots, automated factories, telecommunications systems, computer-controlled vehicles, and computer-controlled consumer appliances such as microwave ovens and sewing machines.

SUMMARY: The design and refinement of an integrated set of models covering both software products and the development environment was completed. These models provide mathematical representations for the important design aspects of the software product. Each of the models addresses decision support and partial automation for the corresponding aspect of software evolution.

The evolution model represents attributes of and dependencies between versions of software components and the analysis and design activities that produce them. This model encompasses plans for future evolution, the current status of ongoing efforts, and the evolution history of the current system, including branching history and parallel lines of development. The software components can include representations of rationale, requirements, architectures, implementations, and other aspects of software systems. The evolution model supports computer-aided planning and cost estimation, automated configuration management, automated team coordination, automated project scheduling, and automated project status monitoring. This model provides a formalism for automatically managing design information (software documents), design rationale (evolution history and dependencies), human resources (design rationale (evolution history and dependencies), human resources (design team, schedules, and work assignments), and plans (proposed software evolution).

PUBLICATION:

Berzins, V., "Computer-Aided Software Evolution Based on Relational Hyper-graph Model," International Conference on Software Engineering, submitted 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: CAPS, Design

AUTOMATED REASONING FOR COMBINING CHANGES
Valdis Berzins, Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: The proposed research will investigate effective automated reasoning support for combining changes to software systems. The capability is relevant for reliably combining the results of concurrently developed enhancements to a software system. Improved decision support in this area should reduce the incidence of software system integration problems. The proposed work will focus on methods for assessing the compatibility of concurrent changes, for suggesting ways to resolve conflicting decisions if the changes are not found to be compatible, and for formulating guard constraints that will ensure concurrent efforts by different designers will remain compatible. The ideas will be validated by developing prototype versions of tools for automatically combining compatible changes, and for diagnosing incompatibilities.

SUMMARY:

The project completed the implementation and evaluation of a method for combining changes to hierarchical design structures. This method is the first of its kind with the ability to automatically detect and automatically recover from conflicts between the independently developed changes to be combined. This is possible in this context because of the following special characteristics of hierarchical software design structures: (1) the extension of the design structure lattice to a Brouwerian algebra preserves the least upper bounds of the original lattice and (2) the semantics of the design (although not its understandability) is independent of the hierarchical structure. The first property ensures that reasoning in the extended algebraic structure is also valid with respect to the embedded model of proper designs, and the second ensures that weakening approximations with respect to the Lattice structure do not throw away practically vital information. Our initial experimental assessments of the implementation indicate that the method is computationally tractable and produces reasonable results.

PUBLICATION:

Berzins, V., "Recombining Changes to Software Specifications," *Journal of Systems and Software,* August 1998.

PROJECT SUMMARIES

AUTOMATED REASONING FOR COMBINING CHANGES TO SOFTWARE SYSTEMS
Valdis Berzins, Professor
Department of Computer Science
Sponsor: U.S. Army Artificial Intelligence Center

OBJECTIVE: The proposed research will investigate effective automated reasoning support for combining changes to software systems. This capability is relevant for reliably combining the results of concurrently developed enhancements to a software system. Improved decision support in this area should reduce the incidence of software system integration problems. The proposed will be validated by developing prototype versions of tools for automatically combining compatible changes and for diagnosing incompatibilities.

SUMMARY: The project completed the implementation and evaluation of a method for combining changes to hierarchical design structures. This method is the first of its kind with the ability to automatically detect and automatically recover from conflicts between the independently developed changes to be combined. This is possible in this context because of the following special characteristics of hierarchical software design structures: (1) the extension of the design structure lattice to a Brouwerian algebra preserves the least upper bounds of the original lattice and (2) the semantics of the design (although not its understandability) is independent of the hierarchical structure. The first property ensures that reasoning in the extended algebraic structure is also valid with respect to the embedded model of proper designs, and the second ensures that weakening approximations with respect to the lattice structure do not throw away practically vital information. Our initial experimental assessments of the implementation indicate that the method is computationally tractable and produces reasonable results.

The project has also developed a method for merging changes to black-box specifications for software modules, expressed using logic. This introduces a boolean difference operator into the logic, which has not been extensively studied and has somewhat surprising properties. Experience with applying the method shows that changes that intuitively seem independent may not actually be independent. The conjecture is that this may be relevant to the feature interaction problem in software requirements.

PUBLICATION:

Berzins, V., "Recombining Changes to Software Specification," *Journal of Systems and Software,* Vol. 42, No. 2, August 1998.

TRAINING SPATIAL KNOWLEDGE ACQUISITION USING VIRTUAL ENVIRONMENTS
Rudy Darken, Assistant Professor
Department of Computer Science
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research program is to determine if virtual environments can be useful for the purpose of acquiring spatial knowledge of specific spaces or for training effective spatial behaviors. This is of particular interest to a wide variety of military communities due to the importance of navigation in many operational tasks. The approach is to conduct a series of experiments using real environmental fidelity, interface fidelity, and training methods in the acquisition of spatial knowledge.

SUMMARY: To date, four studies have been completed (one FY97, three FY98) in this program. Three primary areas were pursued: (1) environmental familiarization of a natural terrain using a portion of the former Fort Ord., (2) environmental

familiarization of an urban terrain using Herrmann Hall, and (3) training navigation skill for helicopter pilots in cooperation with HS-10 at NAS North Island. The research has shown that virtual environments are clearly not a panacea for learning about spaces. In fact, subjects who used the virtual environments tended to perform significantly worse on navigation tasks than subjects who used only a map. Future studies will investigate why this occurs and how to remedy this situation. Early work with HS-l0 indicated that virtual environments might be a powerful tool for training junior pilots how to navigate from a contour map, thus improving their performance in any environment on any mission.

PUBLICATION:

Darken, R., Allard, T., and Achille, L., "Spatial Orientation and Wayfinding in Large-Scale Virtual Spaces: An Introduction," *Presence: Teleoperators and Virtual Environments,* 7(2), pp.101-107, 1998.

CONFERENCE PRESENTATIONS:

Sullivan, J., Darken, R., and McLean, T., "Terrain Navigation Training for Helicopter Pilots Using a Virtual Environment," Third Annual Symposium on Situational Awareness in the Tactical Air Environment, Piney Point, MD, 2-3 June 1998.

Goerger, S., Darken, R., Boyd, M., Gagnon, T., Liles, S., Sullivan, J., and Lawson, J., "Spatial Knowledge Acquisition from the Maps and Virtual Environments in Complex Architectural Spaces," 16th Applied Behavioral Sciences Symposium, U.S. Air Force Academy, Colorado Springs, CO, 22-23 April 1998.

Darken, R. and Banker, W., "Navigating in Natural Environments: A Virtual Environment Training Transfer Study," Virtual Reality Annual International Symposium, VRAIS '98, Atlanta, GA 1998.

THESES DIRECTED:

Sullivan, J., "Helicopter Terrain Navigation Training Using a Wide Field of View Desktop Virtual Environment," Master's Thesis, Naval Postgraduate School, September 1998.

Goerger, S., "Spatial Knowledge Acquisition and Transfer from Virtual to Natural Environments for Dismounted Land Navigation," Master's Thesis, Naval Postgraduate School, September 1998.

Cevik, H., "Map Usage in Virtual Environments," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface, Modeling and Simulation, Other (Training)

KEYWORDS: Virtual Environments, Training, Navigation

MANAGEMENT SYSTEM FOR HETEROGENEOUS NETWORKS (MSHN)
Debra Hensgen, Associate Professor
Taylor Kidd, Associate Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: Research and design effort directed at solving the fundamental problems associated with and creating a distributed metacomputer.

SUMMARY: In 1998 MSHN completed its second year and started its third year of work. During this year, the co-investigators at the University of Southern California and Purdue completed new and fundamental work in the scheduling of complex tasks in heteorogeneous and non-deterministic environments. The co-investigator, Cynthia Irvine, Naval Post-

graduate School Department of Computer Science, continued to explore the ramifications and issues associated with handling security in a SMSHN like environment. At NPS, ground breaking work was performed in several areas, generating several student theses and a number of published papers. Areas of emphasis for 1998 included, among many others of equal importance: (1) development of a mechanism for the monitoring of low-level resource usage via wrappers, (2) determination of the CORBA mechanisms that are mature enough for MSHN use, (3) development of a mechanism for secure communications between MSHN components, (4) the ramifications of non-deterministic resource usage on scheduling decisions, and (5) the determination of the fidelity required in modeling the OS network and CPU allocation policies. In addition, the MSHN team made several presentations and demonstrations to a variety of activities, including Quorum PI meetings, including the Naval Surface Warfare Center (NSWC), University of Texas at Arlington, Teknowledge Corporation, and SPAWAR.

PUBLICATIONS:

Kresho, J., Hensgen, D., Kidd, T., and Xie, G., "Determining the Accuracy Required in Resource Load Prediction to Successfully Support Application Agility," *Proceedings of the 2nd Conference on European Parallel and Distributed Systems* (EURO-PD '98), Vienna, Austria, July 1998.

Xie, G., Hensgen, D., Kidd, T., and Yarger, J., "SAAM: An Integrated Network Architecture for Integrated Services," *Proceedings of the 6th International Workshop on Quality of Service*, Napa Valley, CA, May 1998.

Freund, R., Gherrity, M., Ambrosius, S., Campbell, M., Halderman, M., Hensgen, D., Keith, E., Kidd, T., Kussow, M., Lima, J., Mirabile, F., Moore, L., Rust, B., and Siegel, H., "Scheduling Resources in Multi-User, Heterogeneous, Computing Environments with SmartNet," *Proceedings of the IEEE Workshop on Heterogeneous Computing Systems* (HCW '98), Orlando, FL, March 1998.

Armstrong, R., Hensgen, D., and Kidd, T., "The Relative Performance of Various Mapping Algorithms is Independent of Sizable Variances in Runtime Predictions," *Proceedings of the 7th IEEE Workshop on Heterogeneous Computing Systems* (HCW '98), Orlando, FL, March 1998.

THESES DIRECTED:

Duman, A., "The Use and Run-Time Overhead of CORBA in MSHN Project," Master's Thesis, Naval Postgraduate School, September 1998.

Schnaidt, M., "MSHN: Design of a Client Library to Monitor Resource Usage," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Heterogeneous Networks, Distributed Computing, Data Staging, Metacomputing

MANAGEMENT SYSTEM FOR HETEROGENEOUS NETWORKS (MSHN):
QUALITY-OF-SERVICE SECURITY STUDY AND MODEL
Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The objective of this research is to study the proposed architecture for the Management System for Heterogeneous Networks and, within the context of the Quality-of-Service task, determine how requirements for security can be addressed.

SUMMARY: This effort investigated the security services to be provided in the context of a Management System for Heterogeneous Networks. A security architecture based upon separation of services into four distinct domains was developed. It is designed to take advantage of possible underlying operating system support for integrity domains. Cryptography was used to provide domain separation. A demonstration prototype was developed using the Intel Common Data Security Architecture.

PUBLICATION:

Wright, R., Shifflett, D.J., and Irvine, C. E., "Security Architecture for a Virtual Heterogeneous Machine," *Proceedings of the 14th Annual Computer Security Applications Conference*, pp. 167-177, Phoenix, AZ, December 1998.

CONFERENCE PRESENTATION:

Wright, R., Shifflett, D.J., and Irvine, C.E., "Security Architecture for a Virtual Heterogeneous Machine," 14th Annual Computer Security Applications Conference, Phoenix, AZ, December 1998.

OTHER

Wright, R., Shifflett, D.J., and Irvine, C.E., "Security Architecture Prototype for Virtual Heterogeneous Machines," code delivered to DARPA integrator (Teknowledge) for the DARPA Quorum/Quite research project, September 1998.

THESIS DIRECTED:

Wright, R.E., "Management System for Heterogeneous Networks Security Services," Master's Thesis, Naval Postgraduate School, June 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Information Systems Security, INFOSEC, Information Assurance, Network Security, Distributed Systems Security

INFORMATION ASSURANCE RESEARCH CHALLENGES
Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The objective of this research is to investigate possible information assurance research initiatives for DoD. Areas to be explored may include: the relationship between security and network management functions; cross fertilization through other disciplines; counter measures to denial of service; and metrics for assurance.

SUMMARY: This effort resulted in two invitational workshops attended by the sponsor and researchers from NPS and elsewhere. The first workshop addressed the problem of security management in large-scale distributed networks. The notion of a centralized security service desk intended to collect sensory data, integrate and analyze data from distributed nodes, and provide security management services was discussed. A few of the challenges associated with developing systems to provide these services were identified in the area of policy management and implementation, data archiving and analysis, visualization, and integration of network security status into command and control architectures. A second workshop, entitled Information Assurance Summer Camp, provided a venue for in depth exchanges on selected topics in visualization, data mining, use of signal processing and other analysis techniques, such as Baysean networks

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer Security, Network Security, Heterogeneous Systems, INFOSEC

CENTER FOR INFOSEC STUDIES AND RESEARCH
Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsors: National Security Agency, Naval Postgraduate School,
Defense Information Systems Agency, and Space and Naval Warfare Systems Command

OBJECTIVE: The objective of this research is to provide sustained support for the development of the NPS Center for Information Systems Security (INFOSEC) Studies and Research (CISR) in the areas of curriculum development, trusted systems laboratory development, faculty development in INFOSEC and information assurance, a visiting professor program, an invited lecture series, academic outreach, and graduate utilization. It provides an integrated approach to INFOSEC research and education that focuses on important problems of DoN, DoD and U.S. Government, thus serving the needs of the warfighter and intelligence community.

SUMMARY: The effort to build a high assurance multilevel secure local area network continued. A system architecture was developed. Design and implementation of system components is ongoing. A high level design and prototype implementation for an executive for a TCB extension was completed.

This research supported a security kernel design using split address space technology to provide high assurance support of threads in an environment intended to create partially ordered privilege domains. This base will be used to support a system for the dynamic adaptation and retooling of software in the context of transaction processing.

In ongoing research, conducted with G. Xie (Naval Postgraduate School Department of Computer Science), the development of protocols and protection techniques to provide confidentiality and integrity for IP datagrams when ATM switching services are located at OSI Layer 2 was investigated.

The broad NPS CISR effort in the area of computer security education continued and included development or improvement of intermediate and advanced graduate courses in computer security, dissemination of course materials using both traditional and electronic media, an invited lecture series on computer security topics, and participation in regional and national computer security education activities. The second Workshop on Education in Computer Security was organized and chaired by NPS CISR staff.

PUBLICATIONS:

Irvine, C.E., Chin, S-K., and Frinke, D., "Integrating Security into the Curriculum," *IEEE Computer,* Vol. 31, No. 12, pp. 25-30, 1998.

Irvine, C.E., Anderson, J.P., Robb, D., and Hackerson, J., "High Assurance Multi-level Services for Off-the-Shelf Workstation Applications," *Proceedings of the 21st National Information Systems Security Conference*, pp. 421-431, Crystal City, VA, October 1998.

Macchione, W.A. and Warren, D.F., "The Macro Virus and Virus Scanning Software: Analysis of Their Interaction," *Proceedings of the 21st National Information Systems Security Conference*, pp. 84-90, Crystal City, VA, October 1998.

Irvine, C.E. and Shockley, W.R., "Roundhouse: A Security Architecture for Active Networks," Naval Postgraduate School Technical Report, NPS-CS-98-002, May 1998.

Irvine, C.E., "Security Issues for Automated Information Systems," *Handbook of Public Information Systems*, G.D. Garson, (ed.), 1998, accepted.

PROJECT SUMMARIES

Irvine, C.E., NPS CISR *Annual Report*, July 1998. Also available at http://cisr.nps.navy.mil/Publications.html.

CONFERENCE PRESENTATIONS:

Irvine, C.E., "Exploitation of a Covert Channel," Workshop on Computer Security Education, Pacific Grove, CA, January 1998.

Irvine, C.E., "Meeting Security Requirements for Global Commerce: Can Education Help?" National Colloquium for Information Systems Security Education, Harrisonburg, VA, June 1998.

Michael, J.B., "Computer Security Issues Related to Using COTS Software," IEEE International Workshops on Critical-Functions Considerations for ISO/IEC 15288 — System Life Cycle Processes: Safety, Off-The-Shelf Items, Quality Management and Engineering Principles," Monterey, CA, 10 August 1998.

Michael, J.B., "Network Security I: Network Security Policy," Fifteenth Annual California Law Enforcement Telecommunications System Training and Technology Conference, Anaheim, CA, 23 September 1998.

Michael, J.B., "Network Security II: Boundary Controllers," Fifteenth Annual California Law Enforcement Telecommunications System Training and Technology Conference, Anaheim, CA, 24 September 1998.

Irvine, C.E., Anderson, J.P., Robb, D.A., and Hackerson, J., "High Assurance Multi-level Services for Off-the-Shelf Workstation Applications," 21st National Information Systems Security Conference, Crystal City, VA, October 1998.

Irvine, C.E., "Do Attack/Defend Exercises Belong in the Classroom?" 21st National Information Systems Security Conference, Crystal City, VA, October 1998.

Macchione, W.A. and Warren, D.F., "The Macro Virus and Virus Scanning Software: Analysis of Their Interaction," 21st National Information Systems Security Conference, Crystal City, VA, October 1998.

OTHER:

Irvine, C.E., "Secure Systems: A Security Penetration Analysis with Clark Weissman," CD ROM containing instructional materials, December 1998.

THESES DIRECTED:

Darroca, G., "Framework for a Link Layer Packet Filtering (LLPF) Security Protocol," Master's Thesis, Naval Postgraduate School, September 1998.

Hackerson, G., "Design of a Trusted Computing Base Extension for Commercial Off-the Shelf Workstations (TCBE)," Master's Thesis, Naval Postgraduate School, September 1998.

Isa, H.R., "Utilizing Hardware Features for Secure Thread Management," Master's Thesis, Naval Postgraduate School, December 1998.

Macchione, W.A., "The Capabilities, Propagation Effects, and Targeting of Computer Systems," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer Security, Network Security, High Assurance Systems, INFOSEC, Education, Research

PROJECT SUMMARIES

STUDY INITIATING DIRECTIVE FOR THE
TRAINING INFORMATION MANAGEMENT SYSTEM (TIMS)
Ted G. Lewis, Professor
Department of Computer Science
Sponsor: U.S. Marine Corps Combat Development Command

OBJECTIVE: The Director, Training and Education Division, Marine Corps Combat Development Command (MCCDC), has tasked his staff to develop a plan to re-engineer current information systems in order to improve the management of Marine Corps training.

SUMMARY: The current collection of information systems supporting the Marine Corps Training and Education (T&E) establishment are legacy "stove-pipe" database systems that marginally support the required reservation, scheduling, training resource tracking, and curriculum development functions. Further, they are not Defense Information Infrastructure (DII) Common Operating Environment (COE) compliant and have only fragile linkages to manpower management systems and other service training management systems. Therefore this study recommended a "re-architecting" of the U.S. Marine Corp Training & Education Information System capable of tracking and managing individual Marines. The results of the study will be used to construct a System Decision Memorandum (SDM) for the development of TIMS applications.

PUBLICATIONS:

El-Rewini, H. and Lewis, Ted, *Distributed and Parallel Computing,* Prentice-Hall, 350 pp., 1998.

Lewis, Ted, "A Rose by Any Other (Domain) Name," *Internet Computing,* pp. 92-93, March-April 1998.

Lewis, Ted, "Why the Economy is So Good?" *Computer,* pp. 110-112, May 1998.

Lewis, Ted, "What to do About Microsoft?" *Computer*, pp.109-112, September 1998.

Lewis, Ted, "The New Economics of Information," *Internet Computing*, pp.93-94, September-October 1998.

Lewis, Ted, "The Legacy Maturity Model," *Computer,* pp.125-128, November 1998.

FORMAL MODELS USED FOR AUTOMATION IN SOFTWARE DEVELOPMENT
Luqi, Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of the proposed research is the design of an integrated set of formal models and methods for automating a wide range of design and development tasks for real-time systems. The methods used will focus on automation of design activities that appear in an evolutionary prototyping approach to software development. The significance of the research is to improve productivity and software quality by enabling a higher level of automation in software development. The result of this research will broaden the definition of automatic programming and will make automatic programming a practical approach for increasing productivity in the software lifecycle. Automated decision support functions used will ensure software quality by decreasing the human effort required and minimizing the incidence of human error. The approach controls the complexity and high degrees of freedom of the software process by using computer aid. Earlier user feedback for validating and refining specifications through trial use of operational system prototypes experimentally ensures that the formal specifications correspond to user needs. Maintenance costs will be minimized by reducing the need to repair requirement errors after system deployment and by using specification-based automatic program correction methods sensitive to both syntax and semantics.

SUMMARY: The project focused on automation of design activities that appear in an evolutionary prototyping approach to software development. This research used a set of state-of-the-art formal methods in software engineering to construct a cohesive set of formal models. These models were used to create and to unify automated processes for computer-aided prototyping. Mathematical models for implementing a set of automated and integrated software tools were developed. This research combines very-high-level specification abstractions and concepts with formal real-time models, automated management of software design data and human resources, transformations, change emerging, and automated retrieval of reusable software components to provide automated methods for generating real-time programs and for coordinating teams of developers.

PUBLICATION:

Luqi, "Formal Models and Prototyping," *Proceedings of the Requirements Targeting Software and Systems Engineering Workshop,* Munich, Germany, April 1998.

THESIS DIRECTED:

Kominiak, J., "Software System Requirements for the Fuel Automation Subsystem of the Integrated Combat Service Support System (ICS3) Using the Computer-Aided Prototyping System (CAPS)," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Prototyping, Software Life-cycle

A NON-INVASIVE ACOUSTIC VITAL SIGNS MONITOR
FOR BATTLEFIELD MEDICAL CARE
Luqi, Professor
Department of Computer Science
Sponsor: Office of Naval Research

OBJECTIVE: To develop a military version of the non-invasive acoustic vital signs monitor (N-AVSM). The Software Engineering Group at the Naval Postgraduate School completed a preliminary requirements analysis and developed a prototype of a wireless acoustic monitor system that could protect babies at risk of Sudden Infant Death Syndrome (SIDS). The technology can be used to build a smart stretcher where casualties could be monitored on the way to the hospital.

SUMMARY: A revised N-AVSM prototype was developed using the Computer-Aided Prototyping Systems (CAPS) and presented to several military officer students for evaluation. Several improvements to the user interface were suggested by the military domain experts to make the N-AVSM more user-friendly to battlefield medical care providers, resulting in the updated user interface. Key additions to the user-interface include facilities for the field technicians to customize the N-AVSM for individual patient. Revised CAPS augmented data flow graphs of the top-level architecture of the new N-AVSM were created, which contain additional functions to process the information input from the updated user-interface. Continued development effort is needed to implement the updated N-AVSM on a PC.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Wireless Acoustic Monitor Non-invasive Acoustic Vital Signs Monitor (N-AVSM), Sudden Infant Death Syndrome (SIDS)

PROJECT SUMMARIES

MODULAR SOFTWARE ARCHITECTURE OF JANUS (A)
Luqi, Professor
Department of Computer Science
Sponsor: U.S. Army Training and Doctrine Analysis Command-Monterey

OBJECTIVE: To modernize the software of the Janus (A) systems into a maintainable and evolvable structure. This research develops: (1) a high-level modular architecture for the existing Janus (A) systems using the Computer-Aided Prototyping Systems (CAPS) and (2) an implementation of the design using the Ada95 programming language. The higher level goal of this research is to evaluate the effectiveness of computer-aided prototyping and software evolution tools when applied to legacy software, as opposed to prototype software that is initially developed in the context of the CAPS system and its prototyping language PSDL.

SUMMARY: The first step was to gain an understanding of the system. Meetings were held with TRAC-Monterey and Janus manuals were gathered. Next, object models of the Janus System was developed to create the modules and associations amongst them. It required a great deal of analysis and focus to mentally transform the currently scattered sets of data and functions into small, coherent and realizable objects, each with its own attributes and operations. Based on feedback from Janus domain experts at TRAC-Monterey, Rolands and Associates, OneSAF Project, Combat21 Project, and the National Simulation Center, the re-engineering team revised the object models for the Janus core elements and developed a 3-tier object-oriented architecture for the Janus System.

PUBLICATION:

Luqi, "Re-Engineering the Janus Combat Simulation System," Naval Postgraduate School Technical Report, NPS-CS-98-007, 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Re-Engineering, Computer-Aided Prototyping, Combat Situation

ENGINEERING AUTOMATION FOR COMPUTER-BASED SYSTEMS
Luqi, Professor
Department of Computer Science
Sponsors: U.S. Army Research Office, Office of Naval Research,
National Science Foundation, and Defense Advanced Research Projects Agency

OBJECTIVE: Building quality computer systems that can meet user needs effectively and reliably is currently a major problem. Formal methods that can be partially or completely automated provide a promising approach to this problem. Engineering of systems with computerized components is an important research area for better quality systems as well as speeding up the construction process.

SUMMARY: A workshop, sixth in a series of software engineering workshops for formulating and advancing software engineering methodologies and techniques, was held in October 1998. The workshop provided an opportunity to explore efficient methods to overcome the problems that have hindered the advance of software practices, and address the design, development, deployment, and analysis of complex systems whose behavior is determined or controlled by software. The workshop provided a bridge between industry and academia. The program provided a balanced view of academic research and industrial developments.

PUBLICATION:

Luqi, "Engineering Automation for Computer-Based Systems," *Proceedings of the U.S. Army Research Office/ National Science Foundation/Office of Naval Research Workshop,* Carmel, CA, 26-29 October 1998.

PROJECT SUMMARIES

CONFERENCE PRESENTATION:

Luqi, "Engineering Automation for Computer-Based Systems," U.S. Army Research Office, National Science Foundation, Office of Naval Research Workshop*, Carmel, CA, 26-29 October 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Engineering

COMPUTER MODELING FOR NETWORK CENTRIC C4I SYSTEMS
Luqi, Professor
Department of Computer Science
Sponsor: Naval Postgraduate School-Institute for Joint Warfare Analysis

OBJECTIVE: To model new C4I capabilities, assess network loads implied by new capabilities, and determine the most effective new capabilities that will become possible with the next generation internet technology.

SUMMARY: This project provides an embedded software solution to expand the capabilities of current, and future communications assets, without impairing the standards, methods, or other capabilities of such assets. The combined talents of the Naval Postgraduate School and Space and Naval Warfare Systems Center have been researching the area of digital network maximization for the past two years. This project, in association with the Office of Naval Research Real-Time Retargeting, Advanced Capabilities Initiative, has progressed beyond initial prototype. The methods, and embedded applications developed have demonstrated a 300% plus increase in effective information transfer across a constrained bandwidth channel (Link 16), while not affecting the current Link 16 architecture. The approach has been to develop a non-network-specific method to maximize throughput, without modification to existing hardware or software in the host environment. This technology was demonstrated, in live, operational systems, in July 1998. The architecture developed for this effort is well suited for addressing security issues, increasing effective communications capabilities, and improving QoS through the dynamic reallocation of tactical network resources (i.e., broadcast time slots).

PUBLICATION:

Luqi, "Autonomous Agents Design for Digital Network Maximization in Joint C4I System," *Proceedings of the Modeling and Simulation of Microsystems, Semiconductors, Sensors and Actuators Conference,* Santa Clara, CA, 6-8 April 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Network Centric, C4I Systems, Real-Time Retargetting Advanced Capabilities

SYSTEM ENGINEERING AND EVOLUTION DECISION SUPPORT
Luqi, Professor
Department of Computer Science
Sponsor: U.S. Army Research Office

OBJECTIVE: The objective of the research is to develop an integrated set of formal models and methods for system engineering automation. These results will enable building decision support tools for concurrent engineering. The research addresses complex modular systems with embedded control software and real-time requirements.

SUMMARY: The focus was on automation of design activities that appear in an evolutionary approach to system development. Decision support for design synthesis, reuse and evolution is emphasized. This research extended recently developed

formal methods in system engineering to construct a cohesive set of formal models. These models are used to create and to connect automated processes for computer-aided prototyping, requirements validation, and design synthesis. Mathematical models for implementing a set of automated and integrated engineering automation tools were also developed. Our work combined very-high-level specification abstractions and concepts with: (1) formal real-time models, (2) automated management of system design data and human resources, (3) design transformation, (4) change merging, (5) automated retrieval of reusable system design components, and (6) automated schedule construction. Automated methods were created for: (1) generating real-time control programs, (2) generating simulation of subsystems, and (3) coordinating concurrent work by engineering teams. The work will ensure design consistency and to alleviate communication difficulties.

PUBLICATION:

Luqi, Chang, C., and Zhu, H., "Specifications in Software Prototyping," *Journal of Systems and Software,* Vol. 42, No. 2, pp. 150-177, August 1998.

THESIS DIRECTED:

Meckstroth, G., "A GUI Interface for Reusable Components Storage and Retrieval in the CAPS Software Base," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Engineering Automation Tools, Decision Support Tools

IMPROVED COMMUNICATION/DECISION SUPPORT
Luqi, Professor
Department of Computer Science
Sponsor: Naval Sea Systems Command

OBJECTIVE: Current aircraft carrier damage control communication systems through the repair lockers require an elaborate hierarchy of verbal communications and redundancy to pass even the simplest forms of direction through the fire party. Often this system breaks down under the weight of its own redundancy or the simple narrow channel through which the communications of the repair locker travel. This project seeks to assess the potential for improved Naval damage control operations using fewer personal by improving communications and decision support technology.

SUMMARY: An evaluation of current video teleconferencing (VTC) technology is complete. Evaluation of barcode technology has reached the product identification stage and for lack of materials, may not be adequately considered in this study. A review of the Smart Ship program has been partially completed. Literature review and interviews with crew and design personnel has provided a wealth of information. Wireless LAN technology has been studied and evaluated at the present state of the art. Evaluation of an expert system using a simple inference engine has been completed and indicates this outstanding technology should be organic to the damage control communication system. A small wireless LAN has been constructed to evaluate the viability of signals between computers utilizing COTS hardware and software to gain a working knowledge of the limitations and capabilities of current technology. A live set up and testing was performed on three forms of video teleconferencing to support tele-training for CVX damage control requirements. A small model of an expert system was constructed to demonstrate the ability to program a logical sequence of routines into a simple program on a PC. A small web has been put up of technology sources that have contributed to the knowledge collected thus far in our research.

PUBLICATIONS:

Luqi, "Software Process Improvement – Lessons Learned," *Proceedings of the Asia Pacific Forum on Software Engineering, International Conference on Software Engineering,* Kyoto, Japan, 21 April 1998.

Luqi, "The Pacific Rim Process Engineering Research," *Proceedings of the Asia Pacific Forum on Software Engineering, International Conference on Software Engineering,* Kyoto, Japan, 21 April 1998.

THESIS DIRECTED:

Rambidis, T., "Security Issues for the Software Evolution Model," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Smart Ship Program, Wireless LAN Technology

RECOGNIZING CAPTIONS OF PICTURES ON INTERNET PAGES
Neil C. Rowe, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: To develop a prototype system that finds the photographs on Internet-World Wide Web pages, finds their captions and indexes them.

SUMMARY: In FY98 the important final phase of processing was added that relates the caption concepts to the image concepts. Domain-independent methods were developed for finding the set of regions most likely to represent the subject of a depictive picture. This required a neural network to rank region candidates, and a combinatorial search to find the region set most likely as a whole to correspond to the subject. This new work is reported in the conference paper. This required considerable work on developing robust image processing software to handle a wide range of captioned images. As before, test examples were used from the Naval Air Warfare Center-Weapons Division (NAWC-WD). The concentration was on the training and analyzing of every region (an average of 100) in every one of the 100 pictures and decide whether it was part of the subject. Work was continued on the natural-language processing component of the MARIE project which is necessary preliminary to the above mentioned work. Another 125 captions were parsed, augmenting the lexicon and occasionally the grammar to handle them. Two good overview papers on the system were prepared and submitted to a journal and a conference.

PUBLICATIONS:

Rowe, N.C. and Frew, B., "Automatic Caption Localization for Photographs on World Wide Web Pages," *Informauon Processing and Management,* Vol. 34, No. 1*,* pp. 95-107, 1998.

Rowe, N.C., "Mapping Between Image Regions and Caption Concepts of Captioned Depictive Photographs," *AAAI-98 Workshop on Representations for Multi-Modal Human-Computer Interaction,* Madison, WI, July 1998.

CONFERENCE PRESENTATION:

Rowe, N.C., "Mapping Between Image Regions and Caption Concepts of Captioned Depictive Photographs," AAAI-98 Workshop on Representations for Multi-Modal Human-Computer Interaction, Madison, WI, July 1998.

DoD KEY TECHNOLOGY AREAS: Human System Interfaces, Other (Software)

KEYWORDS: Images, Captions, Digital Libraries, Information Filtering, Content Analysis

PROJECT SUMMARIES

ARTIFICIAL INTELLIGENCE FOR TERRAIN-DATABASE INTEGRATION
Neil C. Rowe, Associate Professor
Department of Computer Science
Sponsor: U.S. Army Training and Doctrine Analysis Command

OBJECTIVE: To develop an intelligent interface to help construct integrated terrain databases by putting together existing simpler databases. The interface will assist the user by analyzing the many options and suggesting the best ones.

SUMMARY: Funding for this project expired several years ago. In CY98 one paper based on the earlier work was reported.

PUBLICATION:

Rowe, N.C., Reed, C., Baer, W., and Jackson, L., "A Planner for Constructing Customized Terrain Databases," *Proceedings of the 1998 Command and Control Research and Technology Symposium*, pp. 481-486, Monterey, CA, June 1998.

CONFERENCE PRESENTATION:

Rowe, N.C., Reed, C., Baer, W., and Jackson, L., "A Planner for Constructing Customized Terrain Databases," 1998 Command and Control Research and Technology Symposium, Monterey, CA, June 1998.

DoD KEY TECHNOLOGY AREAS: Human System Interfaces, Other (Software)

KEYWORDS: Terrain Databases, Data Structures, Software Integration

DISTANCE LEARNING DEGREE PROGRAM: MASTER OF SCIENCE
IN COMPUTER SCIENCE/SOFTWARE ENGINEERING
Neil C. Rowe, Associate Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: To support the distance learning program on software engineering.

SUMMARY: Funding supported work with a student at SPAWAR in San Diego and preparation of a paper with a former student from SPAWAR-SD.

PUBLICATIONS:

Rowe, N.C. and Schiavo, S., "An Intelligent Tutor for Intrusion Detection on Computer Systems," *Computers and Education,* Vol. 31, pp. 395-404, 1998.

Rowe, N.C. and Galvin, T., "An Authoring System for Intelligent Tutors for Procedural Skills," *IEEE Intelligent Systems,* Vol. 13, No. 3, pp. 61-69, May/June 1998.

Barrus, J. and Rowe, N.C., "A Distributed Autonomous-Agent Network-Intrusion Detection and Response System," *Proceedings of the 1998 Command and Control Research and Technology Symposium,* pp.577-586, Monterey, CA, June 1998.

PROJECT SUMMARIES

AN ENVIRONMENT FOR DEVELOPING SECURE SOFTWARE
Dennis M. Volpano, Associate Professor
Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsors: Defense Advanced Research Projects Agency and Information Technology Office

OBJECTIVE: The project aims to develop new techniques to statistically analyze code targeted for remote execution for secure flow violations.

SUMMARY: A technique was developed that attempts to construct a proof, for a given program, in a sound flow logic. If such a proof can be constructed then the program is secure. The technique permits remote code, written in Web-based languages like Java and JavaScript, to be analyzed prior to execution in order to determine whether it can be executed safely.

PUBLICATIONS:

Volpano, D. and Smith, G., "Confinement Properties for Programming Languages," *SIGACT News*, Vol. 29, No. 3, pp.33-42, September 1998.

Volpano, D. and Smith, G., "Language Issues in Mobile Program Security, in Mobile Agents and Security," G. Vigna, (ed.), *Lecture Notes in Computer Science*, Vol. 1419, pp. 25-43, 1998.

CONFERENCE PRESENTATIONS:

Volpano, D., "Probabilistic Noninterference in a Concurrent Language," 11th IEEE Computer Security Foundations Workshop, Rockport, MA, 1998.

Volpano, D., "Confinement Properties for Programming Languages," Office of Naval Research Workshop on Security Directions, Alexandria, VA, September 1998,

Volpano, D., "Confinement Properties for Programming Languages," Stanford Computer Security Seminar Series, Palo Alto, CA, 17 November 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Secure Information Flow, Remote Evaluation

TYPE SYSTEMS FOR SECURE REMOTE EVALUATION
Dennis M. Volpano, Associate Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: This is a joint project with Geoffrey Smith at the Florida International University (FIU). The work is part of a continuing project aimed at investigating the role of programming language design and type systems in ensuring the security of servers in remote evaluation systems. The long-term objective is to identify how languages should be designed in order to guarantee provable confinement properties for all programs expressed in these languages.

SUMMARY: Two forms of information flow were treated in systems: flows arising from synchronization in a concurrent language and probabilistic timing channels due to probabilistic thread scheduling. Techniques were developed in each case to eliminate them in systems. Two secure flow properties were identified as a result. One is Possibilistic Noninterference and the other is Probabilistic Noninterference.

PROJECT SUMMARIES

PUBLICATIONS:

Volpano, D. and Smith, G., *"Probablilistic Noninterference in a Concurrent Language,"* *Proceedings of the 11th IEEE Computer Security Foundations Workshop (CSFW)*, pp. 34-43, June 1998.

Smith, G. and Volpano, D., "Secure Information Flow in a Multi-Threaded Imperative Language," *Proceedings of the 25th ACM Symposium on Principles of Programming Languages (POPL)*, pp. 355-364, January 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORD: Security

WORKSHOP ON PROVABLY-SECURE PROGRAMMING
Dennis M. Volpano, Associate Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The aim of the workshop was to explore the relationship between the design of programming language and security models.

SUMMARY: The workshop was held in Monterey CA, 26-28 March 1997. Its official title is the 1997 Foundations for Secure Mobile Code Workshop. The workshop had around 25 attendees from industry and academia. They were asked to prepare position statements which were provided in advance to all attendees on the web. Statements addressed basically two types of security problems: protecting servers from mobile code and protecting mobile code from malicious servers. The latter problem was viewed as more intractable, given the need for mobile code to rely on an execution platform of some sort. Participants presented their positions and discussion followed. All presentations and discussions were recorded for future reference, however, a final report was not written.

DOD KEY TECHNOLOGY AREA: Computing and Software

KEYWORD: Security

SAAM: NETWORK MANAGEMENT SYSTEM FOR INTEGRATED SERVICES
Geoffrey G. Xie, Assistant Professor
Department of Computer Science
Sponsors: Defense Advanced Research Projects Agency, National Science Foundation and
National Aeronautics and Space Administration

OBJECTIVE: A novel server and agent based active management system will be developed for the next generation Internet.

SUMMARY: The project team was built up by recruiting one full-time research assistant and six graduate students. The overall architecture of SAAM was developed and identified the important issues that the project should focus on. Work was started on developing a SAAM server. (The present prototype uses the Microsoft NT Server as the development platform.) Designed, implemented and evaluated a preliminary version of the Path Information Base (PIB) was designed, implemented, and evaluated. Work was started on prototyping a SAAM lightweight router. An experimental gigabits ATM switch was obtained through a NSF funded program. The switch provides an open platform for implementing and testing SAAM ideas.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: SAAM, Path Information Base

PROVIDING APPLICATION LEVEL QUALITY OF SERVICE
Geoffrey G. Xie, Assistant Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of the research is to design networks that guarantee application-level quality of services (QoS) to multimedia applications.

SUMMARY: Application-level guaranteed statistical services for real-time traffic were designed and evaluated. Specifically, admission control and loss management algorithms were developed for such services based on a novel traffic model for real-time traffic. Two papers have been published on this topic. A security framework was also designed suitable for fast IP touting based on OSI Layer 2 switching. Two theses have been produced on this topic.

PUBLICATIONS:

Xie, G.G. and Lam, S.S., "An Efficient Network Architecture Motivated by Application-Level QoS," *Journal of High Speed Networking*, IOS Press, Netherlands, Vol. 6, No. 3, pp. 165-179, January 1998.

Xie, G.G. and Lam, S.S., "Real-Time Block Transfer Under a Link Sharing Hierarchy," *IEEE/ACM Transactions on Networking*, Vol. 6, No. 1, pp. 205-218, February 1998.

Xie, G.G., Hensgen, D., Kidd, T., and Yarger, J., "SAAM: an Integrated Network Architecture for Integrated Services," *Proceedings of the 6th IEEE/IFIP International Workshop on Quality of Service*, Napa, CA, May 1998.

Kresho, J., Hensgen, D., Kidd, T., and Xie, G., "Determining the Accuracy Required in Resource Load Prediction to Successfully Support Application Agility," *European Conference Proceedings of the 2nd IASTED on Parallel and Distributed Systems*, July 1998.

Xie, G.G., "SAAM: A Network Management System for the NGI," *Proceedings of the 1998 NASA/NREN Workshop on QoS*, NASA Ames Research Center, CA, August 1998.

Xie, G.G., Hensgen, D., Kidd, T., and Yarger, J., "Efficient Management of Integrated Services Using Path Information Base," Department of Computer Science, Naval Postgraduate School, May 1998.

CONFERENCE PRESENTATIONS:

Xie, G.G., Hensgen, D., Kidd, T., and Yarger, J., "SAAM: An Integrated Network Architecture for Integrated Services," 6th IEE/IFIP International Workshop on Quality of Service, Napa, CA May 1998.

Xie, G.G., "SAAM: A Network Management System for the NGI," 1998 NASA/NREN Workshop on QoS, NASA Ames Research Center, CA, August 1998.

THESES DIRECTED:

Kondou, I., "A Protocol for Building a Network Access Controller (NAC) for 'IP over ATM'," Master's Thesis, Naval Postgraduate School, September 1998.

PROJECT SUMMARIES

Darroca, G., "Framework for a Security Protocol in OSI Layer 2 Switching," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications

KEYWORDS: Network Management, Integrated Services, Multimedia, Quality of Service (QoS), Real-Time Data, Agent Technology, Network Security